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Investigation of Geomagnetic Field Forecasting and Fluid Dynamics of the Core

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1. Problems

The first problem mentioned in Progress Report #2 (lack of a graduate research assistant to work on this project) is being solved by the appointment of Miss Margaret Coulter as a one-half time Graduate Research Assistant beginning 15 January 1981. With her dual bachelors degree in Physics and Mathematics from the University of California-Berkeley in 1980, she appears very well qualified to assist this project.

No new scientific obstacles have arisen, but a financial-contractual problem exists because the total costs of the Principal Investigator's trip to Goddard Space Flight Center to attend the recent MAGSAT Investigations Status Meeting (4,5 December 1980) was $712.22, whereas the contract budget for travel is $500.00 (for the entire 32-month duration of the contract). A separate letter to the Contract Administrator (Mr. Perry W. Beilke of ONR-Albuquerque) requesting permission to reallocate funds within the contract so as to cover, fully, the cost of this trip, is expected to resolve this problem.

Permission (and funds) for foreign travel to the proposed MAGSAT session at the IAGA meeting in Edinburgh (July-August 1981) also needs to be requested.

2. Approach

No changes have occurred in the approaches described in earlier Progress Reports. However, a new approach is being taken to the thorny question of how best to decide where to truncate spherical harmonic representations of geomagnetic data. The idea is simply to evaluate some aspect of interest (two examples are given below) at successively higher levels of truncation and then to choose that value of truncation level, N, which gives the most reasonable appearance of "convergence." This approach cannot be defended on rigorous mathematical grounds but is, in our view, the only sensible one to adopt for practical purposes.

3. Accomplishments

a. Truncation Level Study. Two examples of the determination of truncation level mentioned above have been initiated and partially completed. Firstly, Dr. Robert A. Langel, has, at the request of the P.I., fit a selection of MAGSAT data (from 5,6 November 1979) at the following truncation levels (here N is mathematical degree and order): 5,7,9,11,13,14,17. For reference to the results, see the letter from Langel to Benton dated 29 September 1980 together with its attached table (this was distributed to all MAGSAT workers in the field modeling group). The interesting result of these calculations is that nearly all of the computed Gauss coefficients up through order and degree 7 show no further change greater than 1 nT as higher degree and order spherical harmonics are added to the representation, but rather more substantial changes occurred between N = 5 and N = 7. The conclusion appears to be that if one is only interested in a relatively low order and degree representation of the data, N = 7 may be an appropriate place to truncate because the addition of higher order terms do not significantly affect the coefficients up through order and degree 7.

It remains to explain why this stability first sets in at N = 7 rather than at some other value of N. To come to better grips with that question, further calculations (at lower N, and filling in some of the missing higher N values) are needed; the P.I. has requested such calculations from Mr. Ron Estes (Business and Technolgical Systems, Inc.).

A second truncation level result has been obtained in an entirely different context. Rather than focussing on the dependence ofindividual Gauss coefficients on truncation level, we (the P.I. with the collaboration of Dr. Lorant A. Muth) have just obtained initial results for the number of critical points of the vertical magnetic field (places where $\partial B_r/\partial\theta$ and $\partial B_r/\partial\phi$ simultaneously vanish) on the core-mantle boundary. These points are of vital importance for the method of evaluating

core fluid motions described in Progress Report #2. As the truncation level N is increased from 5 to 12 in the 1975 main field model of Barraclough, Harwood, Leaton and Malin, we find the number of critical points N_c varies as follows:

N	5	6	7	8	9	10	11	12
N_c	20	25	30	39	56	72	98	113

Maximum stability (corresponding to the smallest change in N_c) appears to be in the vicinity of N = 7. In this calculation, clearly a complicated weighted sum of Gauss coefficients is involved, yet a similar result to the other one is obtained.

These two calculations bear further bolstering, and will be the subject of some further effort.

b. <u>Downward Extrapolation Through the Electrically Conducting Mantle</u>. We have virtually finished the study of how one corrects for mantle conduction the vacuum extrapolation of the poloidal geomagnetic field downward to the core-mantle boundary. The problem is described in Progress Report #2. What has been accomplished since is the evaluation of the integral in equation (5) of that report for a variety of mantle conductivity profiles. The results confirm the conjecture made on page 6 of that report, namely, that the effective conductivity is not a strongly sensitive function of the poorly known actual conductivity at the mantle base.

No graphics are yet available, but following another week or two of work, we will begin preparing a manuscript for publication (to be included, we hope, with the next Progress Report) under the title:

"A perturbation solution for extrapolation to the core of the poloidal geomagnetic field and its secular variation"

4. Significant Results

The preliminary determination of the onset of relative numerical stability at a truncation level of [illegible] 7 in two independent studies is thought to be a potentially significant result of practical value for field modeling. It requires further substantiation and explanation before dissemination.

5. Publication

The 32-page manuscript entitled "Inviscid, Frozen-Flux Velocity Components at the Top of Earth's Core from Magnetic Observations at Earth's Surface: A New Methodology," included with Progress Report #3, has been accepted for publication, probably in the July 1981 issue of Geophysical and Astrophysical Fluid Dynamics. The editor has requested that it be Part 1 of a two-part paper, where the second part will give numerical results of applying the techniques to data (a suggestion we intend to implement).

6. Recommendations

None.

8. Data Utility

The Principal Investigator found the discussions of the MAGSAT data set at the December Investigators Meeting both interesting and useful. As a result, several requests for auxiliary data are in process. Dr. Joseph Cain's polar plots of the MAGSAT orbits, Dr. Masahisa Sugiura's tabulation of Dst during the MAGSAT mission, and microfilm MAGSAT fine altitude latitude plots (from Dr. Kent Hills) are all being acquired.